Progress Report: Planetary Boundary Layer Height Studies with CALIOP
NASA Award Number, NNX10AM26G entitled, PLANETARY BOUNDARY LAYER
HEIGHT STUDIES WITH CALIOP
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Accomplishments

This is the progress report for the first 1.5 years of the University of Wisconsin Planetary Boundary Layer Height studies using CALIOP. The proposed research focuses on the development and application of a planetary boundary layer height detection algorithm for CALIOP. Accurate measurements of the Planetary Boundary Layer (PBL) height constitute a valuable data set for understanding boundary layer processes as well as to validate global weather forecast models. The first year of this project was focused on beginning the development of a PBL height detection algorithm, the second year has focused on making the algorithm run autonomously on large data sets, as well building a validation data set using the ACARS[1]/AMDAR[2] profile data from aircraft on approach or after takeoff at 3 major US airports. Our specific tasks for year 2 are:

- Continue algorithm development and testing. Deliver version 1 code to CALIPSO data processing center for testing.
- Conduct validation campaigns.
- Continue investigation of PBL and water surface temperature relationships.
- Continue investigation of PBL and lake-land breezes relationships.
- Produce a first version climatology of PBL heights over the Great Lakes.

As will be presented, significant progress has been made in the development of a an automated algorithm and production of a validation data set.

Algorithm developments

The first version of the PBL retrieval algorithm, while proving to be robust, required that it ran on pre-selected cases that were known to be mostly free of clouds and terrain changes. The updated algorithm still operates on the CALIPSO level 1 profile data, however it now screens for clouds in the profile, eliminating those profiles from the average. As part of this effort a new algorithm to detect the surface return on the full resolution (333 m horizontal) profile data was created, such a data product is not available in the standard CALIPSO data products. The PBL height algorithm is sensitive to any step changes in the profile data, thus it is critical that we can distinguish between surface and cloud signals and remove them from the profile data.

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[1] Aircraft Communications Addressing and Reporting System
[2] Aircraft Meteorological Data Reports

Global analyses

With these improvements it is now possible to run the PBL height algorithm on regional or global data sets. As a next step in assessing the performance of the lidar PBLH retrieval we have run the algorithm on 6 months of data, June, July, August 2006 and 2007, to do a qualitative analysis of the seasonal average PBLH height, these results are shown in figure 1. As this data has not be validated, caution should be exercised in interpreting these results, it should also be noted that over regions where BL is not convective the values are not representative of the PBLH. The retrieved PBLH do however look quite promising, as they are similar to what has been observed over different geographical regions.
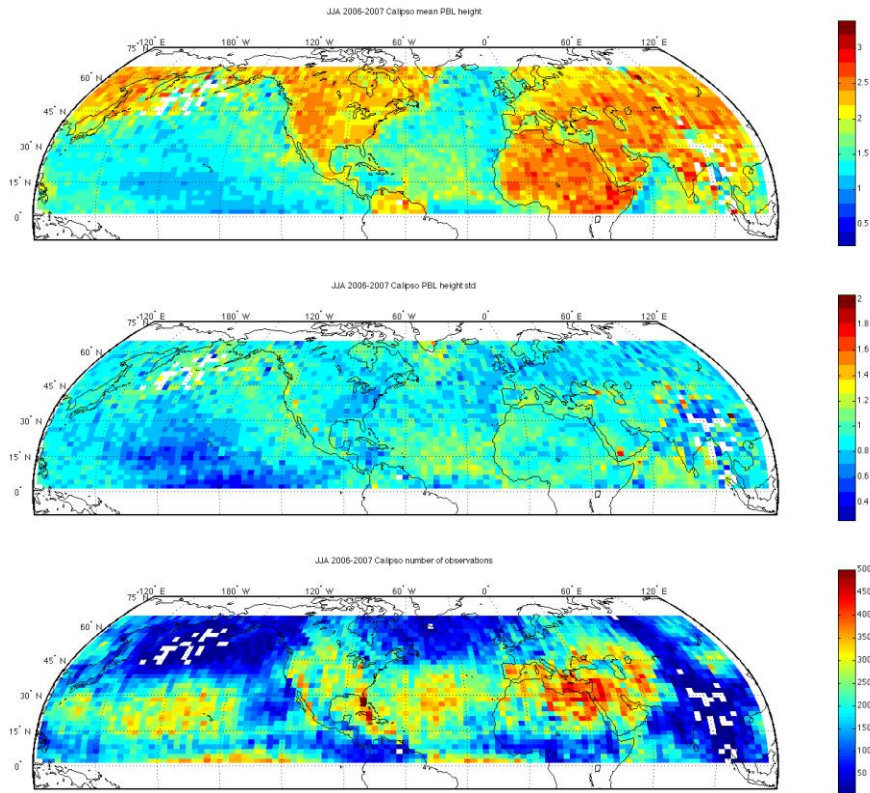

Figure 1: PBLH statistics are for the northern hemisphere, June-July-August, years 2006 and 2007. The mean, standard deviation, and number of observations for each grid box for the top, middle, and bottom figures, respectively.

AMDAR retrievals

The contribution of the United States to AMDAR is called Meteorological Data Collection and Reporting System MDCRS. MDCRS is funded jointly by the U.S. Government and the seven participating airlines (American, Delta, Federal Express, Northwest, Southwest, United, and UPS). These U.S. data are also sometimes called ACARS. Most aircraft provide latitude, longitude, time, altitude, temperature, wind speed

and direction. The altitude-determining physical variable is pressure, which is converted to altitude by using a standard atmosphere. We have completed ingesting 5 years of the AMDAR data for the major U.S. airports, Chicago, Atlanta, Las Vegas and Miami and fine-tuning our AMDAR PBLH retrieval algorithm. Results of this automated processing is shown in Figure 2 (right side), potential temperature vs altitude plots. The aircraft data within +/- 1 hour of the CALIPSO overpass closest to the airport are collected and a potential temperature profile generated, outlying points are screened using a Grubbs test. We then use the algorithm in [2] to determine the top of PBL from the potential temperature profile.

Here are shown results from one case study of our automated retrievals from both the lidar wavelet transform and the AMDAR potential temperature retrieval (Figure 2, left) the yellow and orange colors of the attenuated backscatter image indicate the enhanced scattering from aerosols in the mixed layer. For the majority of the profiles the lidar retrieval performs well, however it is clear in 3 instances (i.e. near 33.6, 34, and 36 latitude) the retrieval is extremely low; the mean PBLH over this range latitude range is ~2500 m. The automated AMDAR retrieval also perform quite well in this instance as it is clear that there is a strong inversion located at 2845 m, note that there is a weaker inversion near 2000 m. As only one aircraft sample was available for this case and CALIPSO closest approach was nearly 80 km west of Hartsfield airport, this comparison is encouraging. Similar case studies from both Atlanta and Chicago provide similar or better agreement.
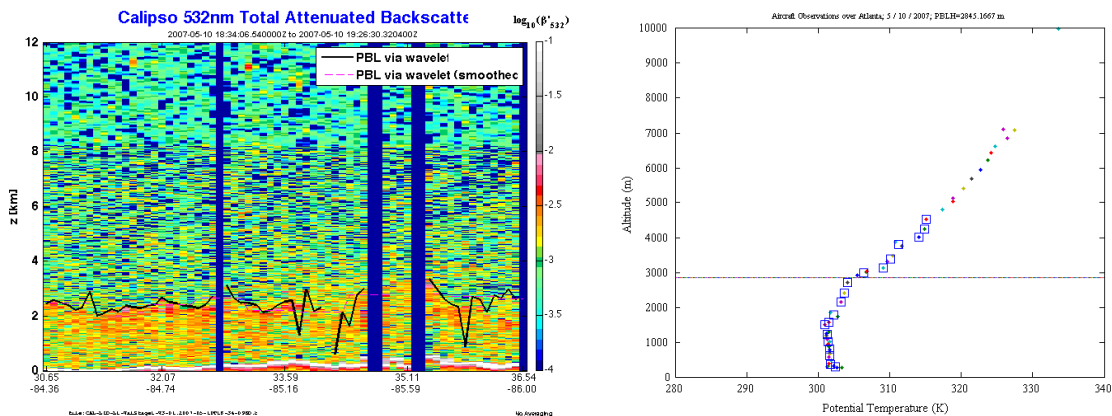

Figure 2. (Left) CALIPSO total attenuated backscatter image near Atlanta (ATL), 2007-05-10, black line indicates PBLH wavelet transform, blue bars are missing data due to cloud clearing. (Right) AMDAR potential temperature profile +/- 1 hour of CALIPSO overpass horizontal line indicates PBLH retrieval.

Summary and Future work

During this last year we have refined our PBLH algorithm and made improvements to allow for automated operation. We have also completed assembling a validation data set of PBLH retrievals from the AMDAR potential temperature profile measurements. In the

near future we will be able to provide 5 year comparisons between CALIPSO-AMDAR retrievals.

Our future work will also involve case studies of the CALIPSO retrievals vs. the NASA Langley airborne high spectral resolution lidar system (LaRC-HSRL) retrievals of PBLH. With our validated data set has been we will use the CALIPSO retrieval results to study the relationship between PBLH and water temperature over the Great Lakes.

References

[1] S. Liu and X.Z. Liang, "Observed Diurnal Cycle Climatology of Planetary Boundary Layer Height," *J. of Climate*, AMS, 23, pp. 5790-5809, November 2010